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ABSTRACT

This discussion of the impact of new computer occupations on women's employment patterns is divided into four major sections. The first section describes the six computer-related occupations to be analyzed: (1) engineers; (2) computer scientists and systems analysts; (3) programmers; (4) electronic technicians; (5) computer operators; and (6) data entry workers. Utilizing published data as well as the 1/1000 Public Use Samples (PUS) from the 1970 and 1980 U.S. Census, section 2 examines the status of women in the six major computer-related occupations and in high tech industries in general. Section 3 uses the 1980 published data and the 1980 PUS sample to investigate the relative earnings of men and women in three computer-related occupations in high tech and non-high tech industries. Six major findings from the study and their implications are discussed in section 4. It is concluded that women need to be made aware of the channeling that leads them into less prestigious, lower paying occupations or industries, and be helped to develop strategies to counteract this movement; however, at the same time efforts must be made to find ways of making occupations and workplaces more welcoming to both genders and more compatible with satisfying personal and family lives. A list of references and nine data tables are included. (JB)

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Institute for Research on Educational Finance and Governance

SCHOOL OF EDUCATION STANFORD UNIVERSITY

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INSTITUTE FOR RESEARCH ON EDUCATIONAL
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Abstract

This paper examines several aspects of gender segregation within three new computer-related occupations. Using data from the Public Use Samples of the 1970 and 1980 Census, we ask: Are these occupations less segregated by gender than are older occupations? Do these occupations provide an opportunity for women to earn higher salaries than women with equivalent years of educational attainment can earn in other occupations? Do these occupations provide an opportunity for women to earn the same salaries as men with equivalent years of education?

Although it is widely believed that new high technology occupations offer more gender equality than do older, established occupations, especially for those with higher education, we find that there is considerable gender segregation in computer-related occupations as well as considerable male-female salary differentiation. We suggest that one of the major causes of the salary differentiation is that men and women in computer occupations are not employed equally across industries; women tend to be employed more frequently in the lower-paying end-user industries.

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We are just beginning to see the repercussions in all of our lives of the technological feat of fitting the electronic wiring and switches of what was a room-sized computer in 1946 onto a less than fingernail-size piece of silicon and metal by the end of the 1970s. This silicon chip is the core of a technological revolution, the result of many attempts over a century to produce a "computing machine" that is small, fast, and cheap. Now, as the chips, and thus the computers they empower, get smaller, faster, and cheaper, their applications in both old and new products are spawning a new high technology industry. We see changes in a multitude of workplaces and homes, the expansion of opportunities in existing industries and occupations, and the creation of new industries and occupations that were not even imagined just a few years ago.

The occupations most involved in the computer revolution are engineers, computer scientists and systems analysts, programmers, electronic technicians, computer operators and data entry workers; these occupations are expanding both within the computer industry and in other industries as well. In addition, the computer industry provides new opportunities for managers, clerical workers, and production workers.

What do the growth of these occupations imply for women's employment? Traditionally women have been sharply segregated into different occupations from men and have been paid less than men (Gross 1968; Lloyd and Niemi 1979; Blau and Hendricks 1979; O'Neill 1983; Bielby and Baron 1984; Strober 1984; Treiman and Hartmann, 1981). Are there better opportunities for gender integration and earnings equity in new occupations that are growing rapidly and exhibit labor shortages, occupations that are supposedly not driven by past traditions and stereotypes? Are there better opportunities for gender integration and pay equity in high technology (high tech) industries?

The paper is divided into four sections. The first discusses the details of the occupations we analyze. The second section uses published

data as well as the 1/1000 Public Use Samples (P.U.S.) from the 1970 and 1980 U.S. Censuses to look at how women are faring in the six major computer-related occupations and in high tech industries. Section three uses the 1980 published data and the 1980 P.U.S. sample to examine the relative earnings of men and women in three computer related occupations in high tech and non-high tech industries. In section four we discuss our findings and their implications.

In brief, we find that although high tech in general and computer occupations in particular are often seen as the great equalizers, especially for those with higher education, in fact there is considerable gender segregation in both high tech industries and computer-related occupations in all industries; there is also considerable male-female earnings differentiation. We suggest that one possible cause of the earnings differentiation is that men and women in computer occupations are not employed equally across industries; women tend to be employed more frequently in the lower-paying end-user industries.[1]

I. Computer-Related Occupations

A. Descriptions of Occupations

The development of semiconductors, computers, and computer languages spawned several new occupations and expanded several others. There are six major computer-related occupation groups--engineers, computer specialists, engineering and science technicians, production workers, computer operators, and data entry operators. Of the six major groups, three are employed only in the computer industry (engineers, engineering and science technicians and production workers) The other three are employed in virtually all industries. The following descriptions of the occupations in these groups are based on definitions in the Standard Occupational Classification Manual, 1980 (U.S. Department of Commerce, 1980), California Employment Development Department publications (ABAG, 1981), and interviews with workers and employment counselors.

1. Engineers design hardware for computers, including the electronic circuits. The largest group of engineers is electrical engineers, but mechanical and industrial engineers also work in the

computer industry. Sometimes they incorporate software designs into the circuits. Engineering is the highest-status and highest-paid computer-related occupation, with engineers generally having at least a B.S. degree in engineering; many have advanced degrees.

2. As we look beyond designing hardware to designing software, the sets of instructions that tell the computer which operations to perform, we encounter the computer specialist occupations. While computer engineers tend to be employed largely by computer companies, computer specialists are employed in virtually every major industry group.These jobs involve a hierarchy of tasks which used to be done by one person with the title of computer programmer.

When the first computer was unveiled in 1946 (it was room-sized because the circuits were made with glass vacuum tubes), the engineers who designed it thought that the main task of arranging the circuits had been done, and that giving instructions to the computer to perform calculations would be a simple clerical task. So they hired people who usually do clerical tasks--women. In this case the women were recent college graduates with math backgrounds. However, these women found that in order to get the computer to do calculations, they (the programmers) had to know all about the design of the circuits and the way those circuits worked in the computer; they had to tell the computer not only what to do, but how to do it. The simple operation of performing calculations (in this case for Navy shell trajectories), became a high level task which involved a knowledge of logic, mathematics, and electronic circuits. These women programmed the necessary calculations, and went on to do others. However, those who watched the programming process began to realize that programming was a high level, challenging and creative occupation. As the occupation grew, it became largely male (Kraft 1979).

Ironically, some programming today is akin to the type of clerical job which computer designers (mistakenly) thought it would be in the late 1940s. Over time, with the development of higher level languages (closer to human languages)[2] and more routine applications, programming tasks that were previously highly skilled, highly paid, and concentrated among highly educated workers, have been broken down into more routine tasks,

distributed among less skilled workers and eventually given over to computers. Kraft (1977) and Greenbaum (1979) have suggested that as this "deskilling" occurs, it is women and racial and ethnic minorities who move into the less skilled jobs.[3]

This history of the developing hierarchy in computer programming is reflected in the designations given by the U.S. Census to the computer specialist occupations. In 1960 and 1970, computer specialists, including programmers, were included in the professional category. By 1980, the Census put the 3-digit occupational category of computer scientists/systems analysts in the professional category and the 3-digit category of computer programmers in the technical category.

The following descriptions attempt to capture the present hierarchy among computer specialists. These job titles and descriptions continue to change and overlap. For that reason it is unclear which job titles were included in the Census categories we used. For instance, it is unclear whether programmers/analysts were grouped with computer programmers or with computer systems analysts.

Computer Scientists and some systems analysts work with engineers to design the overall hardware and software systems, and sometimes know just as much about the hardware, although their training is more concentrated in the logic and mathematical models of computer systems, rather than on electronic principles. They also develop new languages to be used by other programmers. Generally, they have an MS or Ph.D. in computer science (CS) or electrical engineering (EE), or both (CS/EE).

Computer systems analysts conceptualize and plan how a business or industrial task, such as automating a payroll or an assembly line, will be solved by computerization. Systems analysts do not write the programs, but make flow charts to show the subtasks which need to be done by people and computers, and their sequence and timing.

Computer programmers are often promoted into systems analysts positions because these positions represent higher level skills, responsibility, and pay than do programming positions. If systems analysts were not previously programmers, their education is either in business or

data processing. There is a debate in this field about whether systems analysts need programming skills or not.

Systems programmers conceptualize and design the operating systems--systems of program which are still principally involved with coordinating all the hardware so that it will run according to certain high level languages. They are responsible for maintaining and modifying the high level software on the system. They generally require a BS, MS, or Ph.D. in CS, EE, or math.

Software programmers or software engineers, as they are increasingly called, design and write programs in high level languages specifically for certain computers. These programs, often called packages, are sold with the computer to make computer use easier for non-programmers. Packages can include such items as games, accounting programs and instructional programs. These can be very creative when they involve conceptualizing and designing new ways to use the computer. Those writing these packages require a good knowledge of the language used to program the package, and good ideas about marketable packages. Consequently, everyone from high school students to Ph.Ds is designing and writing software.

Programmer/analysts maintain individual operating systems and write programs which apply the computer to uses in their own workplace. Although ready-made software is available for many purposes, most firms need programmers to modify or write programs which reflect their own computing needs. These programmers need to know both operating systems and high level languages. Education requirements are a BA in related subjects with some programming experience, a BS in CS or an MBA.

Programmers, sometimes called coders or applications programmers, are mainly translators. They take the instructions for a certain application in one language and translate them into the programming language which their particular computer will use to produce the same results. They do not usually program the operating system. The job category itself encompasses a range of skills and creativeness from routine coding of sections of an application program to a task more like a programmer/analyst, depending upon the industry and firm they are in.

These jobs can be done with less than a BS in CS although in competitive areas, people with higher degrees are hired.

3. A third major group of computer-related workers is engineering and science technicians. This group is found in the computer industry and is mainly made up of engineering technicians trained in electronics, although there are also some science technicians working within the industry. The electronic technicians have enough specialized knowledge of electronics to be able to construct, test and repair the circuitry and components of computers which the engineers design, and to understand engineering specifications and problems. Although they don't do original design work, they operationalize designs, test them, and then advise engineers on possible modifications. They work both in research design and in production to test and troubleshoot both new and existing products. Also included in the engineering technician category are drafters, who, using both manual and computer assisted drafting tools, make drawings of the circuit boards and components which the engineers design. The standard degrees are an AA/AS for engineering or science technician, and an AA in drafting for a drafter.

4. The fourth computer-related occupational group is computer operators. They are employed in all industries. Computer operators run the external operation of the computer, ensure that the computer gets the programs and data, and coordinate disks, tapes and printing connections to the computer, either manually or by supervising automated systems. This occupation ranges from active high-level interactions with the programs to routinized supervision of automated systems. It is sometimes an entry-level job leading to low-level programming. Education needed is simple knowledge of the equipment from a short training course and/or from experience. The occupation is rapidly being deskilled as more of its functions become automated.

5. Data entry operators, the fifth computer-related occupation, put information into a form which can be read by a computer. This information used to be keypunched onto cards, but is now almost always put onto tapes or disks from terminals. The operators, who basically type numbers and

letters into a terminal, require training in typing. They are also employed in all industries.

6. The sixth major computer-related occupation is production worker. While many of the production jobs are similar to those in other industries, the following jobs are unique to semiconductor and computer production. There are generally no specific educational requirements for these jobs, although in competitive labor markets people with some knowledge of electronics are preferred. Often hazardous chemicals are used in the production process.

Semiconductor processors put materials through chemical and mechanical processes to create semiconductor integrated circuits on chips. They work either manually or, as these tasks become mechanized, with processing machines.

Semiconductor assemblers assemble chips into wired devices which become the complete integrated circuit. This includes bonding wires to circuits, a task which is done under a microscope, and cleaning the circuits with chemicals.

Electronic assemblers assemble the integrated circuits and other electronic components into a frame which becomes the finished product (eg. a computer). Electronic assemblers can be promoted to electronic testers, who test chips, boards and components as they go through assembly, or electronic inspectors, who examine the components for errors and specification requirements.

A skilled occupation which is sometimes part of production and sometimes in customer service is data processing repairing, installing and repairing data processing machinery in offices and on production lines. This job category includes a range of workers from electronic mechanics to assembly and wiring technicians.

There are also, of course, sales, managerial, and professional occupations within the computer industry. These jobs tend to be similar to such jobs in other industries.

II. Gender Segregation

A. Computer-Related Occupations

Table I gives the total number employed and the percentage of women employed in the total labor force and in computer-related occupations in 1970 and 1980.[4] Between 1970 and 1980, employment in computer-related occupations grew about 80 percent--from about 1.5 million to 2.4 million. However, although the growth of these occupations is widely heralded, it is important to note that they represented only 2.0 percent of all employment in 1970, and 2.5 percent in 1980.

In 1970, women were 38 percent of the U.S. labor force; in 1980, they were 43 percent. In both those years, women's representation in computer-related occupations was either considerably below or considerably above their representation in the labor force as a whole. Despite the fact that the computer-related occupations are of relatively recent origin, they are already remarkably segregated by gender.

In 1970, women were 2 percent of all engineers in the computer industry; in 1980, that figure had risen to only 5 percent. Thus, in the highest paid, highest prestige computer-related occupation, women are virtually absent.

Among computer specialists in all industries, the situation is somewhat better, although women are still below their proportion in the overall workforce. In 1970, women were 15 percent of all computer scientists/systems analysts. This occupation more than doubled from 1970-1980 (from 93,000 to 200,700), but by 1980, women were only 22 percent. Among programmers, the proportion of women also increased, but they were also still underrepresented. The number of programmers almost doubled (from 161,000 to 313,000), and the proportion of women grew from 23 percent in 1970 to 31 percent in 1980.

Women were better represented among engineering and science technicians in the computer industry than among engineers, but were less well represented than among computer specialists. In 1970 in the computer industry, women were 11 percent of engineering and science technicians; in 1980 they represented 17 percent. They were similarly represented among electronic/electrical technicians--11 percent in 1970 and 15 percent in

1980. As drafters, women did less well in 1970 than other technicians--only 7 percent were women-- but did better in 1980, when 16 percent were women.

Initially, there was no clear indication as to which gender would be assigned to the occupation of computer operator. In 1960, when there were only 2,000 computer operators, women held 65 percent of the jobs (Dicesare, 1975). Between 1960 and 1970, the jobs in this occupation increased more than 50 fold, to 117,000. More of these new jobs were filled by men than by women so that in 1970, women were only 29 percent of all computer operators. In the period from 1970 to 198', however, while the occupation increased four-fold, to 408,000, more of the new additions to the occupation were women, so that in 1980, women were 59 percent of all computer operators.

Like most clerical occupations, data entry is preponderantly female. In 1970 women were 90 percent of data entry operators. Between 1970 and 1980 the occupation became even more segregated so that by 1980 women represented 92 percent of such operators.

Of all production workers in the computer industry, women were only slightly over their representation in the labor force as a whole: 46 percent in 1° 0 and 49 percent in 1980. However, when we look more closely at the less skilled production occupations, women's representation is much higher. Of all the operatives, fabricators, laborers, and transportation workers, a group which includes the semiconducto processors and assemblers and all other lower level production workers in the computer industry, women represented 58 percent in both 1970 and 1980. Among assemblers, a sub-set of operatives, women were about 73 percent in 1970 and 1980. Of electronic assemblers, a group identified only in 1980, women were an even higher proportion: 77 percent.[5] However, in the occupation "data processing machine repairers," we find again the extraordinary gender segregation we often see in technical occupations: women held 3 percent of these jobs in 1970, 8 percent in 1980.

B. Gender, Race, and Ethnic Distribution i' To . Computer-Related Occupations

If we look more closely at the four computer-related occupations which are present in all industries--computer scientists/systems analysts,

computer programmers, and data entry operators--we can see how women and men in the three largest racial and ethnic groups are represented. Table II shows that in the employed labor force as a whole, white men are 50 percent of the workers, white women are 36 percent, black men are 4.8 percent, black women are 4.8 percent, and other racial groups make up 8.4 percent of the workers. Men and women of Spanish origin, who can be of any race, represent 3 and 2 percent of the workers respectively.

In the occupations of computer scientists/systems analysts and computer programmers, women of all groups and minority men are underrepresented compared to their representation in the labor force as a whole, while white men are overrepresented. Within each racial and ethnic group, men are better represented than women.

In the highest paid category, computer scientists/systems analysts, white men hold 71.3 percent of the jobs, much higher than their representation of 50 percent in the labor force. White women occupy 19.5 percent of the jobs, only half as high as their representation in the labor force. Black men are less represented in this occupation than in the labor force (3 percent versus 4.8 percent). Black women's representation is even poorer, with 1.7 percent in computer scientists/systems analysts versus 4.8 percent in the labor force. People of other races are only about half as well represented in this occupation as in the labor force. Like black men, the representation of men of Spanish origin is just over half that of their presence in the labor force (1.8 versus 3 percent). Women of Spanish origin are virtually unrepresented; they are only .1 percent of computer scientists/systems analysts, though they are 2 percent of the labor force.

Among computer programmers, the next lower paying occupation, white men are still overrepresented, and the other groups are still underrepresented, but somewhat less so. White men are overrepresented by 10 percentage points (62.2 percent versus 50 percent) and white women are underrepresented by 10 percentage points (26.5 percent versus 36 percent). Black men's representation is still 3.1 percent, but black women's representation has increased to 2.5 percent. However, both percentages are below their share of the labor force. Other racial groups have also increased their representation, but it is still below their labor force

representation. Men and women of Spanish origin have virtually the same representation among computer programmers as among computer scientists/systems analysts--1.8 and .1 percent respectively.

This situation changes and in some cases reverses itself in the lower paying occupation of computer operators. White men are now only one third of the workers, 10 percentage points less than in the labor force, and white women are now half of the workers, 15 percentage points above their representation. Black men's representation is about the same as in the labor force, and black women's representation is higher among computer operators (6.9 percent) than in the labor force (4.8 percent). People of other racial groups are still underrepresented, however. Men of Spanish origin have a representation among computer operators just below their labor force percentage, while the percentage of women of Spanish origin is slightly above their percentage in the labor force. Thus in this lower paid computer occupation, white and black women and women of Spanish origin are slightly overrepresented, and white men are underrepresented, while the percentage of black men and men of Spanish origin reflects their percentage in the labor force as a whole.

When we look at the lowest paid computer occupation of data entry operator, a clerical occupation, we see that all women's representation is dramatically higher and all men's representation dramatically lower than for the other occupations listed in Table II. White women are 71 percent of data entry operators, twice their labor force representation. Black women and women of Spanish origin are represented in this occupation with a frequency three times greater than their representation in the labor force, 16 and 6 percent respectively.

Like gender, race and ethnicity of workers in computer occupations is associated with pay and status of the occupation. The higher status and pay of an occupation, the more white men are overrepresented, and the more minority men and all women are underrepresented. In occupations with lower pay and status, the presence of white men drops to much below their percentage of the labor force, the percentage of women of all races becomes higher than their labor force percentage, and the percentage of minority men approaches their labor force representation. In an occupation which is

clerical, women's representation doubles and triples above their labor force percentage, and men virtually disappear.

C. High Tech Industries

This section looks at how women are faring not just in computer-related occupations but in the group of industries known as high tech, of which the computer industry is one part. We are interested in whether or not the computer industry and other high tech industries, because they are growing rapidly and are relatively new, are therefore perhaps less gender stereotyped and more hospitable to women than are non-high tech industries.

The Bureau of Labor Statistics recently reviewed all current definitions of high tech industries, and developed a range of definitions based on three factors: "(1) the utilization of scientific and technical workers, (2) expenditures for research and development, and (3) the nature of the product of the industry." (Riche, et al., 1983).

Different combinations of these factors produced three groups of high tech industries, from the least inclusive definition with 6 three-digit industries, to the most inclusive definition with 48 three-digit industries. We use as our definition of high tech industries the middle group of 28 three-digit industries: 26 manufacturing industries (including computers and semiconductors) with a proportion of technologically-oriented workers equal to or greater than the average for all manufacturing industries and a ratio of R & D expenditure to sales close to or above the average for all industries, and two non-manufacturing industries that provide technical support to high tech manufacturing industries (computer and data processing services, and research and development laboratories). (Riche et al. 1983). A list of the industries designated as high tech may be found in Appendix I.

We find, however, that these industries are no less segregated by gender than are other industries, and in fact may be even more so. Table III demonstrates that employment in high tech industries has grown over the 1970-80 decade from 4.6 million to 6.1 million. In both 1970 and 1980, high tech industry employed only about 6.5 percent of all employed workers, about 5 percent of all women workers and about 7.4 percent of men workers.

Table IV shows that in both 1970 and 1980, most men in high tech industries were in management, professional/technical work, or in production, while most women were in clerical work or production. Compared to women in non-high tech industries, women in high tech industries are less likely to be in managerial and professional/technical jobs, and much more likely to be in production work. High tech industries provide lower status occupations to women, as a group, then do non-high tech industries. By contrast, men in high tech industries are more likely to be in managerial or professional/technical positions than are men in non-high tech industries.

III. Analysis of Relative Earnings of Women and Men in Three Computer-Related Occupations

A. Uncorrected Earnings Differentials

To examine salary differences between women and men we analyze three computer-related occupations where at least 20 percent of the jobs are held by the "minority gender"--computer scientists/systems analysts, computer programmers, and computer operators.[6] We find that even when women are employed in the same occupations as men, they do not receive the same pay.

We used two sources to calculate the gender differential in pay--the published Census reports, where the only available measure was the mean annual earnings, and the Census P.U.S. samples, where we could calculate the median hourly earnings. With each source, for the years available, we calculated the ratio of the women's earnings to men's earnings for each of these three occupations in all industries combined. As each source has both advantages and disadvantages, we present data from both.

The advantage of using the published Census reports is that they are more accurate than the samples. The disadvantages are that only the mean annual earnings are available for 1980, and the mean is a poor estimate of average earnings since it is so influenced by a few high values. In addition, since the median was used as an estimate for most of the comparable occupations in 1970, the two years could not be compared, except in the combined category of computer specialist. Another disadvantage is that the use of annual earnings precludes controlling for part-time or part year workers.

The advantages of using the Census samples are that we could calculate the median, the most accurate estimate for average earnings, for each occupation and year; and could control for part-time and part year workers by calculating the hourly earnings.[7] The disadvantage is that the estimates were subject to large standard errors.

Interestingly, the two sources of income data produced simlar and consistent results. Table V contains the uncorrec' ' gender differentials in pay based on the published Census data. In the first two columns are the numbers (in thousands) of total employees (men and women) in each occupation in 1970 and 1980. The second two columns show percentage of all employees who were women in each year. The next four columns show, for the years it was available, the mean annual earnings of men in that occupation, and the ratio of women's mean hourly earnings to men's earnings. This ratio is the gender differential in pay for each occupation, with no controls for education or experience.

For the combined computer specialist occupations, the uncorrected ratio of women's to men's mean annual earnings was .72 both in 1970 and in 1980. This constancy of the ratio is noteworthy as employment more than doubled over the ten year period and the proportion of women in these occupations increased by 50 percent.

In 1980, the uncorrected ratio of women's to men's mean annual earnings was available for the three occupations. For both computer scientists/systems analysts and computer programmers, the ratios were .73. For computer operators the ratio was .65. Since these were not corrected for part-time or part year workers, we would expect the ratio estimates which did have these corrections to be somewhat higher, and they were.

Table VI contains the gender differentials in pay based on the P.U.S. samples, corrected for part-time and part year workers but not for education or experience. In the first two columns are the sample numbers of men and women employed in each occupation in 1970 and 1980. These numbers are the samples upon which the earnings estimates are based. The second four columns show, for each year, the median hourly earnings of men in the occupation, and the ratio of women's median hourly earnings to men's earnings.

For the occupation computer scientist/systems analyst, the ratio of women's to men's median hourly earnings was .75 in 1970, and .74 in 1980. Again, such constancy is noteworthy since employment more than doubled over the decade. It is also interesting that correcting for part-time and part year workers does not increase this differential to much above the estimate from the published data for computer specialists.

Among programmers, there was still a gender differential after correcting for part-time and part year workers, earnings, although smaller than that for computer scientists and systems analysts. The ratio of women's to men's median hourly earnings was .85 in 1970, .83 in 1980--again, remarkably constant given the more than doubling of employment in the occupation.

For computer operators there was a rise in the differential with the correction for part-time and part year workers. In 1970, when women had only 29 percent of the jobs, the female/male ratio of median hourly earnings was .73. By 1980, the gender division of labor had reversed and women dominated the occupation, with 59 percent of all the jobs. Still, the earnings ratio was .69, quite close to what it had been ten years earlier.

Although the sources are based on different measures and samples, they both show that women earn substantially less than men in these three occupations and that these ratios do not change much over time. Clearly, earnings equity is not an automatic result of the existence or the growth of these occupations.

Despite the fact that women earn less than men in computer programming and computer science/systems analysis, professional computer-related occupations are financially attractive for women. Relative to what professional women earn in other occupations requiring similar years of educational attainment, computer programming and systems analysts positions enable women to earn at the top of the female earnings hierarchy. Table VII shows that for women in 1981, computer systems analysts was the second-highest paying occupation, computer programming the seventeenth highest. In both of these occupations, women earned more on average than they did in secondary school teaching (Rytina, April 1982), despite the

fact that in 1980 the mean educational attainment was only 15.75 years for women systems analysts and only 14.88 years for women computer programmers. For women secondary school teachers, the mean educational attainment was 16.43 years (P.U.S., 1980).

B. Earnings Regressions

Earnings differentials between women and men in the same occupations are in part a result of differences between women's and men's human capital and productivity and in part a result of wage discrimination (lower payment to women even after human capital and productivity have been held constant). To what extent is wage discrimination against women present in the relatively new computer occupations? Does employment in a high-tech industry lessen wage discrimination within the computer occupations?

In order to answer these questions, we ran OLS regressions for the three computer-related occupations in 1970 and 1980, on the natural log of hourly earnings using the P.U.S. samples. The independent variables we used to proxy human capital and productivity were determined by the availability of data. The Census 1/1000 P.U.S. reports age, years of education, and gender, but not years of work experience, type of degree or field of college major. We used AGE and AGE^2 as continuous variables. We divided years of education into six categories, reflecting the fact that number of years of education affects one's position in the labor market in a discontinuous fashion. The categories are: eight years or less; some high school; high school graduate; some college; college graduate; and more than a college degree. The category "some college" was the reference group and was omitted from the regression.

These variables have some serious deficiencies as indicators of education and productivity. Although age is often used as a proxy for work experience, a component of human capital, age is less likely correlated with years in the labor force for women than it is for men, and is therefore a less than satisfactory proxy for experience. Level of education, although frequently used as a measure of human capital and productivity, says nothing about the quality or type of education. Because our controls for human capital and productivity are problematic, the gender variable is a poor measure of discrimination.[8] We use age and level of

education as control variables only because we have no others; we have traded-off poor human capital proxies for the relatively large samples of these three occupations which the Census provides.

In addition to human capital variables the regressions have two dummy variables: GENDER (equal to one for women) and HTECHIND (equal to one for those employed in a high tech industry). The combined effects of the human capital variables and the two dummy variables on salary were tested in an additive model.[9]

For computer scientists/systems analysts in 1970, age, education, gender, and industry type explained 20 percent of the variance in the log of hourly earnings (see Table VIII); however, only having a college degree and older age were significantly related to earnings. By 1980, only 10 percent of the variance was explained by these four factors. Age and a college degree still significantly increased earnings, but gender less significantly decreased earnings. Holding the other variables constant, having a BA or BS increased one's salary by 27 percent while being a woman decreased it by 20 percent. The drop in explained variance suggests that by 1980 other unmeasured factors were beginning to affect salaries for this occupation. Being in a high tech industry was not significantly related to earnings for computer scientists/systems analysts.

For computer programmers, we saw a more dramatic trend. In 1970, education, age, industry and gender explained almost none of the variance. However, by 1980, 20 percent of the variance was explained by these factors and all but industry type were significantly related to earnings. Age, and having a BA/BS, and more than a BA/BS significantly increased earnings, while gender, somewhat less significantly, decreased earnings. The changes in the effects of age and education may reflect the formalization of qualifications for this occupation; whereas earlier, people with diverse education and experience were recruited and trained into it, by 1980 there were more formalized career ladders and more institutional training in the field. The beginning of an effect based on gender suggests that some differences based on gender may also have been in the process of becoming institutionalized. For programmers, being in a high tech industry did not appear to affect salaries when other variables were held constant.

Computer operators show a different pattern. For both 1970 and 1980, 16-20 percent of the variance was explained by age, industry, education and gender. Being a woman decreased one's salary significantly in both years. In 1970, gender was the only significant variable in the regression; being female, all other variables held constant resulted in a 70 percent decrease in salary. By 1980 higher age and working in a high-tech industry also contributed significantly to higher earnings, but education was still not significant. In 1980, the effect of gender on salary, while still highly significant, was much smaller (27 percent) than it had been in 1970. These results reflect the fact that this occupation has few educational requirements, that training is largely on the job, and that jobs in high tech industries pay more. However, it also points out that women with the same education and age are still paid less than men, and that this was true both when the occupation was predominantly male (in 1970) and when it was predominantly female (in 1980).

C. <u>A Closer Look at Earnings and Employment Differences by Industry</u>

How does the labor market operate to pay men and women differentially even when they are in the same occupation, and are similar with respect to age and level of education? In her book on clerical employment, Francine Blau (1977) reports that often women and men in the same occupation in the same city earn different salaries because they work for different firms--women for low wage firms and men for high-wage firms. It may be that, analogously, women and men in computer occupations earn different salaries in part because they work in different industries--men in high paying industries and women in lower paying "end-user" industries.

These differences may not have shown up in the reported regressions because the industry dummy variable divided industries into only two groups, high tech and non-high tech. Unfortunately, the P.U.S. sample sizes in each industry are too small to include major industry groups as variables in the reported regressions. However, Table IX, based on the Census publication, <u>Occupation by Industry</u> shows that within these three computer-related occupations in 1980, women and men are not employed in equal proportions across major industry groups.

In the first column of Table IX we find the estimated number of total employees (men and women) in each occupation by industry. The second column contains the percentage of women in the occupation for each industry. The third column shows the men's mean annual earnings in the occupation by industry. In the fourth column we have calculated the ratio of the women's mean annual earnings to men's mean annual earnings for each industry. The first row of each occupation contains these data for all industries combined. The second row isolates these data for part of the computer industry, based on the Census 3-digit industry category, "Electronic Computing Equipment Manufacturing." The remaining rows show the data in the major 2-digit industry groups. Several industry groups (agriculture, forestry and fishing; mining; construction; personal services, and entertainment and recreation) have been removed from the analysis altogether because they employ so few persons in computer-related occupations.

As shown in Table IX, women are 22.3 percent of computer scientists/systems analysts, in all industries, but only 14.9 percent of computer scientists in electronic computing equipment manufacturing. Among the major industry groups listed in Table IX, the percentage of women employed ranges from 16.9 percent in mining to 35.6 percent in finance, insurance and real estate. For all industries, the men's mean annual earnings for computer scientists/systems analysts is $23,405; earnings figures are not available for electronic computing equipment manufacturing. Among major industry groups, men's mean annual earnings range from a low of $20,296 in professional and related sciences to a high of $26,031 in mining. Note that in mining, where the percent women employed is lowest, men's earnings are highest; conversely, where the percent women employed is highest (in finance, insurance and real estate) men's earnings are the second lowest.

To examine the relationship between the percent women and men's mean annual earnings across major industry groups we computed a rank correlation coefficient. For computer scientists/systems analysts the rank correlation coefficient is -.95, significant at the 99 percent confidence level. However, because the sample sizes are relatively small, we also computed

the rank correlation coefficient taking into account the standard errors of the percentages and means.[10] The corrected rank correlation coefficient is -.68, not significant at the 95 percent confidence level.

The ratio of female/male earnings (F/M) for computer scientist/systems analyst is .73 for all industries and ranges from .69 in manufacturing to .82 in transportation, communications and public utilities. The data do not suggest a relationship across industries between F/M and percent women or between F/M and men's mean annual earnings, mainly because of the lack of wide variation in the F/M ratio.

Among computer programmers, women are 31.1 percent of employees in all industries but only 22.0 percent in electronic computing equipment manufacturing. As in the case of computer scientists/systems analysts, women are more likely to be employed in end-user industries. Across major industry groups, the percent women employed ranges from 26.5 in manufacturing (which includes the manufacturing of electronic computing equipment) to 36.6 percent in finance, insurance and real estate. Men's mean annual earnings are $17,967 for all industries; among major industry groups, they range from a low of $12,353 in professional and related services to a high of $19,704 in transportation, communications and public utilities. However, unlike the situation for computer scientists/ systems analysts, neither the uncorrected nor the corrected (for standard error) rank correlation coefficient show a significant relationship between percent women and men's mean annual earnings.

The ratio of F/M earnings for programmers does not vary very much across major industry groups. The ratio for all industries is .73; for all but one major industry group, the F/M earnings ratio is within a few percentage points of the mean. However, in professional and related services the ratio is .83. It is interesting that in this industry men's earnings are the lowest for all of the industries listed.

Among computer operators, women are 59.0 percent of those employed in all industries, but only 46.6 percent of those employed in the manufacture of electronic computing equipment. As in the case of computer scientists/systems analysts and computer programmers, women computer operators are more likely to be employed in end-user industries than in the

computer manufacturing industry. Among major industry groups, the percent of women employed ranged from a low of 42.9 percent in mining to a high of 68.8 percent in construction.

Men's mean annual earnings were $14,203 for all industries and ranged from a low of $10,024 in professional and related services to a high of $17,067 in transportation, communications and public utilities. There is no systematic relationship between men's mean annual earnings and percent women.

The ratio of F/M earnings for computer operators was .65 for all industries. As in the case of the other two occupations discussed, the F/M earnings ratio did not vary much across industries. The only "outlier" was in the professional and related services industry where the ratio was .80. And, as in the case of computer programmers, this industry had both the highest F/M earnings ratio and the lowest men's mean annual earnings.

Our data suggest that in computer occupations, women are more likely to be found in end-user industries than the computer manufacturing industry itself. In some occupations, particularly computer scientists/systems analysts, women also may be more likely to be found in industries where men are lower-paid.[11] However, it is not possible at this point to test this hypothesis definitively. If we were to disaggregate industry groups further, the sample sizes would become even smaller and the standard errors would rise accordingly.

IV. Conclusions

A. Findings

1. Despite the fact that computer-related occupations are of recent origin, they are not gender-neutral. The computer field was sired by the fields of mathematics and engineering and the newly born prestigious and technical jobs quickly took on the gender designation of the parent fields. Computer engineering and electronic technical work have very few women. On the other hand, data entry, which quickly took on the characteristics of clerical work, became a virtually exclusive female preserve. Production work, too, is preponderantly female (see Table I).

Computer programmers were female when the occupation first emerged, but very shortly after the computer was introduced, men began to fill the

emerging jobs. Although women have increased their representation in the jobs of both programmer and analyst, women remain less than a third of the incumbents of these occupations. While the occupation of computer operator did not seem to be immediately gender typed, in that it was preponderantly female in 1960 and male in 1970, it was becoming preponderantly female again by 1980.

2. Among four computer related occupations found in all industries--computer scientists/systems analysts, computer programmers, computer operators, and data entry operators--the higher the status and pay of the occupation, the more white men were overrepresented compared to their representation in the labor force as a whole and the more minority men and women of all racial and ethnic groups were underrepresented. In occupations with much lower pay and status, the presence of white men dropped to much below their percentage in the labor force, the percentage of women of all racial and ethnic groups became much higher than their percentage of the labor force, and the percentage of minority men approached their labor force representation (see Table II).

3. Within high tech industries, most men were in production, professional/technical, or managerial occupations, while most women were in production or clerical occupations. Women and men were equally likely to be in production occupations. However, men were more likely to be in managerial and professional/technical occupations in high tech industries than in non-high tech industries; women fared worse in these occupations in high tech industries than in other industries (see Table IV).

4. Within the occupations of computer scientists/systems analysts, computer programmers, and computer operators, women's mean annual earnings and women's median hourly earnings were less than those of men. In addition, the ratios of women's to men's earnings generally remained constant between 1970 and 1980 (see Tables V and VI).

5. Within the three occupations analyzed, women's hourly earnings were generally less than those of men even after age, level of education, and high tech versus non-high tech industry were held constant (see Table VIII).

6. Women employed as systems analysts, programmers and computer operators were more likely to be found in end-user industries than in the computer manufacturing industry itself. Within the three computer-related occupations, women were paid less than men no matter in what industry they were employed (see Table IX). In some occupations, particularly computer scientists/systems analysts, women may be more likely to be found in industries where men are lower-paid. However, this hypothesis has not been tested definitively here.

These findings dispel the myth that high tech is automatically a great equalizer. High tech may produce integrated circuits, but it does not necessarily produce an integrated work force or eliminate the female/male earnings differential.

B. Discussion

A detailed explanation of these findings is beyond the scope of this paper. Several theories have been proposed to explain occupational segregation and earnings differentials by gender (see Blau and Jusenius 1976; Cain 1976; Amsden 1980; Sokoloff 1980; and Strober 1984). These theories focus on women's own behavior, on employer discrimination, and on the interactions of labor markets and gender relations in society. It is likely that all of these theories explain aspects of the pattern of gender segregation and earnings differentials reported here and that several different types of policies will be required if we wish to change these patterns.

More research on the dynamics of each aspect of gender segregation would allow us to design more effective policies. More detailed research on the differences in women's employment between and within industries and between and within firms would identify the bottlenecks toward the gender integrati . c occupations. Attention needs to be given to the processes by which women are allocated, and/or allocate themselves into the lower paid occupations and industries. This involves investigating how employers structure and define occupations and career ladders and distribute skilled job applicants and workers in ways that result in gender segregated occupations and industries. Research also needs to be done on the degree to which technologically-trained women (and some men) self-select out of

certain occupations or industries because a certain definition or culture for the occupation or industry precludes respect for the participation of people with different work styles or cultures.

As compared to men, women still are more likely to exclude themselves from advanced science and math training; DeBoer (1984) argues that even when women in high school and college science perform at a higher level than their male classmates they have a higher drop out rate from science than do men. He proposes that teachers in secondary and post-secondary education make special efforts to let talented women know how skilled they are.

However, Sally Hacker's work (1981) suggests that merely encouraging women may not be sufficient to change their educational decisions, that women's decisions to exclude themselves from technical fields may be related in part to a dislike of the fields' "culture". Hacker, based on research at a technical institute, argues that there is a "culture of engineering" which includes an extension of the profession's formal objectification and control of the natural world to an informal objectification of women.

It may be that a distaste for being part of the "engineering culture" also leads technically trained women to exclude themselves from certain sectors of the computer industry. If an engineering culture appears most strongly in those sectors and industries of the computer field that are at the technological forefront and most competitive technologically, then it may be that those sectors and industries are the least appealing to women. However, it may not be accidental that these sectors have the strongest engineering culture. In terms of Strober's theory (1984), men who work in these intellectually challenging and highly lucrative sectors may develop the "engineering culture" in part precisely to keep women out.

The work style and work pressures in the most technologically competitive sectors of the computer industry may also keep many women out. While firms in all industries must remain competitive with similar firms, the computer industry, a new industry with constant technological breakthroughs, has some unique pressures: to make and increase profits in a competitive non-oligopolistic environment, stay on the technological

forefront, and stay ahead of not only young and old domestic companies, but their Japanese counterparts as well. These financial and technological pressures are intensified as each firm tries to survive and succeed before the industry "shakes down". There is much pressure on workers in the computer industry to maintain high levels of productivity, including overtime work and other forms of commitment to the success of the firm. Women who want to succeed have to put in long, hard hours of work, and this may be a barrier for women (and men) who are trying to balance their home and work lives.

Even as we encourage more women to train for the highly technical computer occupations, we need to disseminate the findings of studies such as this. Women need to be made aware of the chanelling that leads them into less prestigious, lower paying occupations or industries and be helped to develop strategies to counteract this chanelling. At the same time, if we are interested in ending gender segregation and attendant gender pay differentials, we need to find ways of making occupations and workplaces more welcoming to both genders and more compatible with satisfying personal and family lives.

NOTES

[1]We define "end-user" industries as those which use the products of the computer industry and make only minor changes to accommodate the products to their needs, rather than making basic new developments in these products. The companies developing computers and/or their software are part of the computer industry. The companies in all other industries, which will use these computers and/or software, are part of end-user industries

It i true that even within the computer industry the administrative divisions f the companies are end-users of computers. However, Census data does ot permit us to make such fine distinctions within industries, and we ar interested here in any broad differences between industries.

[2]Note tha higher level languages are closer to human languages and hence easier to in programming. Thus, paradoxically, "higher" level languages require lower skill and have lower prestige associated with their use.

[3]Braverman (1974) originally identified and labeled this process as the "degradation of work". It soon became known as "deskilling".

[4]This table contains two levels of aggregation--computer-related occupations found mainly within the computer industry, and those found in all industries. For the three occupational groups within the computer industry (engineers, engineering and science technicians, and production workers), we used the published U.S. Census Population Characteristics Special Report, Occupation by Industry for 1970 (Table 8) and 1980 (Table 4). The computer industry was defined as two 3-digit industry categories: Electronic Computing Equipment and Electrical Machinery, Equipment, and Supplies, n.e.c. (which includes semiconductors). For the computer-related occupations which were represented in all industries, we used the same reports, Table 8 (1970) and Table 1 (1980). The notes for Table I indicate the detailed occupational categories used for each occupational group.

[5]In Silicon Valley in 1981, 40 percent of women assemblers were ethnic minorities (Rogers and Larsen, 1984). This production occupation is even more segregated if we consider the thousands of women, but absence of men, employed as assemblers in American electronics factories abroad (Grossman, 1980).

[6]Although production workers also qualified under the criterion, we did not study them, because they are only "computer-related" if they are in the computer industry, and isolating that industry would have created too small a sample. In addition, we wanted to compare computer-related occupations

across industries, and computer-related production workers by definition cannot be in other industries.

[7] Hourly earnings were calculated by dividing each person's yearly salary (from the year prior to the Census year) by the number of weeks worked (in the year prior to the Census) and dividing that by the hours they worked in an average week. Because the data are based on the respondents' estimate of the average hours worked, the data are subject to possible errors.

[8]See Strober and Reagan (1982) for a discussion of the problems of using regression techniques to measure discrimination.

[9]We also ran regressions with the education and high tech variables interacted with gender, testing a multiplicative model. However, since no interactions were significant in 1980, since the few interaction terms that were significant in 1970 could have been so by chance, and since most residuals in the additive model were acceptable, we followed the usual statistical practice of reporting the more parsimonious model. (See Chatterjee and Price, pp. 78-85). While the residuals for computer operators in 1970 were improved by adding interaction terms to the equation, we used the additive model for this occupation and year for consistency, and because these interaction terms could have been significant by chance.

When variables are added to an equation not from an a priori expectation of their effect but rather merely to test for their effect, as in the case here, there is a 5 percent chance that a significant effect may occur only by chance. The more variables, the more chance that one or more will be falsely significant. Likewise, the more regression equations, the more chance that one will contain falsely significant variables. (See Wonnacott and Wonnacott, pp. 88-94.) Since the equation with the interaction terms had 15 variables in it, and was run six times (for three occupations in two years), it seemed likely that the few interaction terms that were significant might well have been so only by chance.

[10]The standard errors for the percentages were calculated from Table B or the formula below the table in Appendix C in Occupation by Industry. This was multiplied by 1.2, the appropriate design effect factor for a crosstabulation of industries and occupations, as shown in Table C of Appendix C. A 95 percent confidence interval was created by calculating two standard errors on either side of the estimate.

The standard errors for means were calculated using the formula in Appendix C, page C-2, for standard errors of means. The variances needed in that formula were not provided by the Census, so a conservative guess was used of a standard deviation equal to 5,000 for all salary distributions. This was squared to produce the estimated variance. A 95% confidence interval was created by calculating two standard errors on either side of the estimate.

[11]Kraft and Dubnoff found similar results in a 1982 survey of "software specialists" in Boston. They found women concentrated in the "worst paying industries" (Kraft & Dubnoff 1983).

REFERENCES

ABAG (Association of Bay Area Governments), "Silicon Valley and Beyond: High Technology Growth for the San Francisco Bay Area. Working Papers on the Region's Economy, 2. Berkeley, CA, 1981.

Amsden, Alice H., "Introduction," in Alice H. Amsden, (Ed.), The Economics of Women and Work. New York: St. Martin's Press, 1980.

Blau, Francine D., and Hendricks, Wallace E., "Occupational Segregation by Sex: Trends and Prospects, The Journal of Human Resources, 14, pp. 197-210, 1979.

Blau, Francine D., and Jusenius, Carol, "Economists' Approaches to Sex Segregation in the Labor Market: An Appraisal," in Martha Blaxall and Barbara B. Reagan, eds., Women and the Workplace: The Implications of Occupational Segregation. Chicago: University of Chicago Press, 1976.

Braverman, Harry, Labor and Monopoly Capital. New York: Monthly Review Press. 1974.

Cain, Glen G., "The Challenge of Segmented Labor Market Theories to Orthodox Theory: A Survey. Journal of Economic Literature, 14 (December), 1976.

Chatterjee, Samprit and Price, Bertram, Regression by Example. New York: Wiley and Sons, 1977.

DeBoer, George E., Factors Affecting the Science Participation and Performance of Women in High School and College. Hamilton, N.Y.: Colgate University, Department of Education, 1984.

Dicesare, Constance Bogh, "Changes in the Occupational Structure of U.S. Jobs. Monthly Labor Review, (March), 1975.

Digest of Educational Statistics, 1983-84.

Forester, Tom, (Ed.), The Microelectronics Revolution. Cambridge: The MIT Press, 1982.

Gilligan, Carol, In a Different Voice, 1982.

Greenbaum, Joan M., In the Name of Efficiency. Temple University Press: Philadelphia, 1979.

Gross, Edward, "Plus Ca Change...? The Sexual Structure of Occupations Over Time". Social Problems, 16, pp.198-208, 1968.

Grossman, Rachael, "Women's Place in the Integrated Circuit". Radical America, 14:1 (Jan./Feb.) pp.29-49, 1980.

Hacker, Sally L., "The Culture of Engineering: Woman, Workplace, and Machine. Women's Studies Int. Quarterly, 4:3, 1981.

Kraft, Philip, Programmers and Managers. New York: Springer-Verlag, 1977.

_____, "The Industrialization of Computer Programming: From Programming to 'Software Production'. In Andrew Zimbalist (ed.), Case Studies on the Labor Process, Monthly Review Press, 1979.

Kraft, Philip and Dubnoff, Steven, "Software Workers Survey". Computer World, November 14, 1983.

Lloyd, Cynthia B. and Neimi, Beth T., The Economics of Sex Differentials. New York: Columbia University Press, 1979.

Riche, Richard W., Heckers, Daniel E., and Burgan, John U., High Technology Today and Tomorrow: A Small Slice of the Employment Pie. Monthly Labor Review, (November), 1983.

Rogers, Everett M., and Larsen, Judith K., Silicon Valley Fever. New York: Basic Books, 1984.

Rytina, Nancy F., "Earnings of Men and Women: A Look at Specific Occupations. Monthly Labor Review (April), 1982.

Sokoloff, Natalie J., Between Money and Love: The Dialectics of Women's Home and Market Work. New York: Praeger, 1980.

Strober, Myra H., "Toward a General Theory of Occupational Sex Segregation: The Case of Public School Teaching. In Barbara F. Reskin, (Ed.), Sex Segregation in the Workplace. Washington, D.C.: National Academy Press, 1984.

Strober, Myra H. and Reagan, Barbara B. "Sense and Nonsense in Measuring Employment Discrimination in Higher Education". Unpublished paper, 1982.

Treiman, Donald J. and Hartmann, Heidi I., Women, Work and Wages: Equal Pay for Jobs of Equal Value. Washington, D.C.: National Academy Press, 1981.

U.S. Dept of Commerce, Office of Federal Statistical Policy and Standards Standard Occupational Classification Manual, 1980.

Vetter, Betty M. and Babco, Eleanor L., Professional Women and Minorities. Scientific Manpower Commission 1978, 1982.

Wonnacott, Ronald J. and Wonnacott, Thomas H., Econometrics, 2nd Edition. New York: Wiley and Sons, 1979.

APPENDIX I.

Industries Within Major Industry Groups, by High Tech and Non-High Tech Categories

(High tech/non-high categories from Monthly Labor Review [Riche, et al., 1983]. Industry groups and titles from 1980 Census Industry Codes.)

HIGH TECHNOLOGY INDUSTRY GROUPS (HIGH TECH):

Durable Manufacturing
Ordnance, engines, turbines, industrial machines, office and accounting machines, computers, electrical equipment and industrial apparatus, radio, TV, communications equipment, electronic components, accessories, and machinery, aircrafts and parts, guided missiles and space vehicles, engineering, laboratory, scientific, and research instruments, measuring and controlling instruments, optical, surgical, medical, and dental instruments, photographic equipment.

Non-durable Manufacturing
Chemicals, plastics, synthetics, drugs, soaps, cleaners, paints, petroleum refining.

Business and Repair Services
Computer and data processing services, commercial research and development laboratories.

NON-HIGH TECHNOLOGY INDUSTRY GROUPS (NON-HIGH TECH)

Durable Manufacturing
Lumber, furniture, stone, clay, and glass products, other metal industries, cutlery, handtools, hardware, other machinery, household appliances, transportation equipment, clocks, toys, sporting goods.

Non-durable Manufacturing
Food, tobacco, textile, apparel, paper, printing, rubber, leather products.

Business and Repair Services
Advertising, buildings services, personnel supply, business management and consulting, detective and protective services, business services, automotive services and repair, electrical repair, misc. repair.

Transportation, Communication, and Public Utilities
Rail, bus, taxi, truck services, warehouses, U.S. Postal Service, water and air transportation, pipelines, misc. transportation services, radio, TV, telephone, telegraph, electricity, gas, steam, and water supplies, sanitary services.

Wholesale Trade
All wholesale trade of durable and nondurable goods, including sale of high tech products.

Retail Trade
All retail outlets for durable and nondurable goods, including sale of high tech products.

Finance, Insurance, and Real Estate
Banking, savings, and loans, credit agencies, securities and investment, insurance, real estate and real estate insurance and law offices.

Professional and Other Services
Offices of doctors, dentists, chiropractors, optomitrists, and other health practitioners and services, hospitals, nursing, and personal care services, legal services, elementary and secondary schools, colleges and universities, business, trade, and vocational schools, libraries, educational services, job training and vocational rehabilitation, childcare services, residential care, social services, museums, art galleries, zoos, religious and membership organizations, engineering, architectural, and surveying services, accounting, auditing, and bookkeeping services, noncommercial educational and scientific research.

Public Administration
Offices of chief executive and legislative bodies and their advisory and interdepartmental committees and commissions, government civil rights and civil service commissions, offices providing support services for government such as accounting, personnel, purchasing and supply, courts, police protection, correctional institutions, fire protection, government legal counsel, public finance, tax, and monetary policy, administration of educational programs, public health programs, social, manpower, and income maintenance programs, veterans' affairs, environmental protection, and housing and urban development programs, regulatory agencies, national security and international agencies.

NOTES:

Detailed occupational categories represented by the occupational titles in Table I, based on the occupatonal 2-digit and 3-digit codes from the 1970 and 1980 U.S. Census:

*Engineers: The 2-digit category of engineer.
The 3-digit category of electrical/electronic engineer.
Computer Specialists: The 3-digit category of computer scientists/systems analyst.
The 3-digit category of computer programmers.
*Engineering and Science Technicians: The 2-digit categories of engineering and science technicians.
The 3-digit category of electrical/electronic engineering technicians.
The 3-digit category of drafters.
Computer Operator: The three 3-digit categories of computer equipment operators and supervisors.
Data Entry Operators: The 3-digit category of data entry operator.
*Production Workers: Over 200 3-digit production occupations, including crafts, precision production, operatives, transportation and laborers. Does not include farm occupations.
*Operatives, Fabricators, Transportation, and Laborers: A subset of production workers. Excludes craft workers and precision production. Not precisely the same occupations in each year.
*Assemblers: The 3-digit category within the operatives group.
*Electronic Assemblers: A 3-digit category in 1980 only, within precision production.
Data Processing Repairers: Within precision production, the 3-digit category of data processing repairer.

*Only reported within the detailed industry groups: Electronic Computing Equipment and Electrical Machinery, Equipment, and Supplies, n.e.c. (includes semiconductors).

TABLE I

Total Employed in the Labor Force
and in Computer-Related Occupations, 1970 and 1980

	1970 Number Employed	1970 Percent Women	1980 Number Employed	1980 Percent Women
Total Labor Force	76,553,599	38	97,639,355	43
Total in Computer-Related Occupations	1,497,461	--	2,424,240	--
*1. Engineers	90,626	2	125,055	5
*Electrical/Electronic Engineers	47,004	2	67,320	4
2. Computer Specialists	254,537	20	513,863	28
Computer Scientists/Systems Analyst	93,200	15	200,684	22
Computer Programmers	161,337	23	313,179	31
*3. Engineering & Science Technicians	58,292	11	90,990	17
*Electronic Technicians	31,454	11	60,299	15
*Drafters	16,963	7	16,726	16
4. Computer Operators	117,000	29	408,475	59
5. Data Entry Operators	272,570	90	378,094	92
*6. Production Workers	680,299	46	872,345	49
*Operatives, Fabricators, Transporters & Laborers	519,221	58	591,091	58
*Assemblers	158,191	74	208,284	72
*Electronic Assemblers	---	--	55,879	77
Data Processing Repairers	30,844	3	46,626	8

Percent of total employed labor force in computer-related occupations

1970	1980
2.0	2.5

SOURCE:
*Only within Computers/Semiconductors Industry: Data from U.S. Census, Population Characteristics Special Report, Occupation by Industry for 1970 Table 8, 1980 Table 4.

All other occupational groups are from all industries. Data from U.S. Census Subject Report: Occupation by Industry 1970 Table 8, 1980 Table 1.

TABLE II

Total Employed and Percentage Distribution by Race, Spanish Origin and Gender in the Labor Force and in Four Computer Related Occupations 1980

	Total Labor Force	Computer Scientists/ Systems Analysts	Computer Programmers	Computer Operators	Data Entry Operators
Total Employed	97,639,355	200,684	313,179	408,475	378,094
White Men	50.0	71.3	62.2	33.9	5.7
White Women	36.0	19.5	26.5	49.5	71.3
Black Men	4.8	3.0	3.1	4.7	1.1
Black Women	4.8	1.7	2.5	6.9	15.1
Other Races	8.4	4.5	5.7	5.0	6.8
	100.0%	100.0%	100.0%	100.0%	100.0%
Spanish Origin* Men	3.0	1.8	1.9	2.4	.1
Spanish Origin Women	2.0	.1	.1	2.8	5.7
Not of Spanish Origin	95.0	98.1	98.0	94.2	94.8
	100.0%	100.0%	100.0%	100.0%	100.0

*Persons of Spanish Origin can be of any race.

SOURCE: U.S. Bureau of the Census 1980 Subject Report Occupation by Industry, Table 1.

TABLE III

Number Employed in High Tech Industries
and Percent of All Employed in 1970-1980

	1970		1980	
	Number Employed	Percent of All Employed	Number Employed	Percent of All Employed
All Workers	4,557,000	6.5	6,060,000	6.4
All Women	1,254,000	5.0	2,026,000	5.1
All Men	3,303,000	7.4	4,034,000	7.4

SOURCE: U. S. Census, 1/1000 P.U.S. Tape, 1970 and 1980.

TABLE IV

Occupational Distribution of Men and Women Employed in High Tech Industries and Non-High Tech Industries in 1970 and 1980

1970

	High Tech Industries		Non-High Tech Industries	
	Men	Women	Men	Women
Managers	10	3	13	5
Professional and Technical	28	6	12	16
Sales	3	<1	8	10
Clerical	9	36	7	33
Services	2	1	8	20
Production	48	55	37	14
Other	2	<1	13	1
	100%	100%	100%	100%
N (in thousands)	3,195	1,205	39,357	23.676

1980

	High Tech Industries		Non-High Tech Industries	
	Men	Women	Men	Women
Managers	14	6	13	8
Professional and Technical	26	10	13	18
Sales	3	1	10	11
Clerical	8	35	7	31
Services	3	2	9	18
Production	44	46	35	11
Other	3	1	12	2
	100%	100%	100%	100%
N (in thousands)	4,034	2,026	50,263	37,729

SOURCE: U. S. Census, 1/1000 P.U.S. Tape, 1970 and 1980.

TABLE V

Employment and Earnings for Men and Women
in Three Computer-Related Occupations in All Industries
1970 and 1930

	Total Number Employed (in 1000's)		Percent Women Employed		Mean Annual Earnings			
	1970	1980	1970	1980	1970 Men's Mean Erngs	F/M Ratio	1980 Men's Mean Erngs	F/M Ratio
Computer Specialists	254,537	513,863	20	28	$11,004	.71	$20,090	.72
Computer Scientists/ Systems Analysts	93,200	200,684	15	22	n.a.	n.a.	23,405	.73
Computer Programmers	161,377	313,179	23	31	n.a.	n.a.	17,967	.73
Computer Operators	117,000	408,475	29	59	n.a.	n.a.	14,203	.65

SOURCE: U. S. Bureau of the Census, 1980 Subject Report, Occupation by Industry, Table 1; and 1970 Subject Report, Occupation by Industry, Table .

n.a. not available

TABLE VI

Employment and Earnings for Men and Women
in Three Computer-Related Occupations in All Industries
1970 and 1980
Based on U.S. Census 1/1000 Samples

	Total Number Employed (sample size)		Median Annual Earnings			
			1970		1980	
	1970	1980	Men's Median Erngs	F/M Ratio	Men's Median Erngs	F/M Ratio
Computer Scientists/ Systems Analyst	105	199	$5.17	.75	$10.19	.74
Computer Programmers/	155	312	$4.10	.85	$ 8.12	.83
Computer Operators	106	456	$3.15	.63	$ 6.38	.69

SOURCE: U. S. Census, 1/1000 P.U.S. Tape, 1970 and 1980

TABLE VII

Occupations with Highest Median Weekly Earnings for Women Employed Full Time in Wage and Salary Work,[a] 1981 Annual Averages

Occupational Title[b]	Female Earnings
Operations & Systems Researchers & Analysts	$422
Computer Systems Analysts	420
Lawyers	407
Physicians, Dentists & Related Practitioners	401
Social Scientists	391
Teachers, College & University	389
Postal Clerks	382
Engineers	371
Ticket, Station & Express Agents	370
School Administrators, Elementary & Secondary	363
Life & Physical Scientists	357
Health Administrators	357
Public Administration Officials and Administrators, Not Elsewhere Classified	337
Vocational & Educational Counselors	336
Registered Nurses	331
Personnel & Labor Relations Workers	330
Computer Programmers	329
Editors & Reporters	324
Secondary Schoolteachers	321
Librarians	318

[a]Excludes earnings from self-employment

[b]Occupations listed are those in which female employment was 50,000 or more in 1981.

SOURCE: Current Population Survey, 1981 (Rytina, 1982)

TABLE VIII

Earnings Regressions for Computer Scientists/ Systems Analysts, Computer Programmers, and Computer Operators 1970 and 1980

	Computer Scientists/Systems Analysts		
	Mean	(Std. Dev.)	B
1970:			
Ln. of Hourly Earnings	1.7	(.44)	
Education: Up to 8 Years	.01	(.10)	.53
Some High School	.02	(.14)	-.23
High School	.29	(.45)	-.05
BA or BS	.23	(.42)	.26**
More than BA/BS	.22	(.42)	.15
Age	34.69	(9.77)	.07***
Age^2	1297.66	(797.95)	-.006**
Gender (=1 if Female)	.14	(.35)	-.07
High Tech Industry	.29	(.45)	.13
Constant			.02
N	105		
Adj. R^2	.20		
1980:			
Ln. of Hourly Earnings	2.16	(.63)	
Education: Up to 8 Years	0	(0)	-
Some High School	.01	(.07)	.21
High School	.13	(.33)	.14
BA or BS	.31	(.46)	.27**
More than BA/BS	.27	(.45)	.15
Age	34.58	(8.39)	.09**
Age^2	1265.98	(637.18)	-.001**
Gender (=1 if Female)	.25	(.43)	-.20*
High Tech Industry	.44	(.50)	.06
Constant			.10
N	199		
Adj. R^2	.10		

TABLE VIII--Page 2

	Computer Programmers		
	Mean	(Std. Dev.)	B
1970:			
Ln. of Hourly Earnings	1.30	(.79)	
Education: Up to 8 Years	0	0	-
Some High School	.02	(.14)	.29
High School	.23	(.42)	.09
BA or BS	.37	(.49)	.07
More than BA/BS	.07	(.26)	.04
Age	29.65	(8.05)	.04
Age^2	943.52	(568.57)	-.0002
Gender (=1 if Female)	.32	(.47)	-.16
High Tech Industry	36	(.43)	.05
Constant			.50
N	155		
Adj. R^2	-.01		
1980:			
Ln. of Hourly Earnings	2.01	(.57)	
Education: Up to 8 Years	0	(0)	-
Some High School	.02	(.15)	-.16
High School	.17	(.38)	-.006
BA or BS	.31	(.46)	.22***
More than BA/BS	.15	(.36)	.24***
Age	32.28	(8.76)	.10***
Age^2	1118.15	(656.98)	-.001***
Gender (=1 if Female)	.29	(.45)	-.12*
High Tech Industry	.32	(.47)	.04
Constant			-.13
N	312		
Adj. R^2	.20		

TABLE VIII--Page 3

	Computer Operators		
	Mean	(Std. Dev.)	B
1970:			
Ln. of Hourly Earnings	1.16	(.67)	
Education: Up to 8 Years	.01	(.10)	-.14
Some High School	.07	(.25)	-.12
High School	.53	(.50)	.02
BA or BS	.01	(.10)	.77
More than BA/BS	.01	(.10)	.12
Age	28.80	(9.40)	.04
Age^2	917.07	(675.91)	-.0004
Gender (=1 if Female)	.21	(.41)	-.70***
High Tech Industry	.25	(.43)	-.10
Constant			.51
N	106		
Adj. R^2	.16		
1980:			
Ln. of Hourly Earnings	1.70	(.58)	
Education: Up to 8 Years	.01	(.10)	.01
Some High School	.04	(.19)	-.16
High School	.48	.50	-.01
BA or BS	.11	(.31)	.04
More than BA/BS	.02	(.15)	.09
Age	32.08	(10.77)	.06***
Age^2	1145.03	(812.62)	-.001***
Gender (=1 if Female)	.53	(.50)	-.27***
High Tech Industry	.20	.40	.18***
Constant			.59
N	456		
Adj. R^2	.20		

*p<.10
**p<.05
***p<.01

SOURCE: U.S. Census P.U.S. tapes, 1/1000 samples for 1970 and 1980.

TABLE IX

Three Computer-Related Occupations in All Industries, Electronic Computing Equipment Manufacturing and in Selected Major Industry Groups in 1980

COMPUTER SCIENTISTS/SYSTEMS ANALYSTS

	Total Employment	Percent Women	Men's Mean Annual Earnings	Ratio of F/M Earnings
All Industries	200,684	22.3	$23,405	.73
Electronic Computing Equipment Manufacturing	22,129	14.9	NA	NA
Mining	2,159	16.9	26,031	.77
Construction	1,500	22.3	22,661	.70
Manufacturing	65,606	17.5	24,093	.69
Transportation, Communications and Public Utilities	12,947	26.8	23,812	.82
Wholesale Trade	8,953	21.4	22,840	.80
Retail Trade	5,336	26.5	22,195	.71
Finance, Insurance and Real Estate	18,051	35.6	21,381	.78
Business Services	46,384	19.9	23,288	.74
Professional and Related Services	15,241	28.4	20,296	.68
Public Administration	23,415	24.4	24,991	.75

TABLE IX-Page 2

COMPUTER PROGRAMMERS

	Total Employment	Percent Women	Men's Mean Annual Earnings	Ratio of F/M Earnings
All Industries	313,179	31.1	$17,967	.73
Electronic Computing Equipment Manufacturing	22,702	22.0	NA	NA
Mining	3,171	32.5	19,455	.76
Construction	2,802	34.8	17,275	.69
Manufacturing	93,010	26.5	19,037	.75
Transportation, Communications and Public Utilities	22,537	34.9	19,704	.78
Wholesale Trade	11,477	32.1	18,064	.67
Retail Trade	10,052	33.6	16,400	.73
Finance, Insurance and Real Estate	39,749	36.6	16,774	.77
Business Services	63,423	28.0	17,826	.72
Professional and Related Services	35,352	34.3	12,353	.83
Public Administration	29,635	35.9	18,868	.74

TABLE IX-Page 3

COMPUTER OPERATORS

	Total Employment	Percent Women	Men's Mean Annual Earnings	Ratio of F/M Earnings
All Industries	408,475	59.0	$14,203	.65
Electronic Computing Equipment Manufacturing	7,175	46.6	NA	NA
Mining	4,647	42.9	16,041	.63
Construction	5,758	68.8	14,833	.67
Manufacturing	98,886	55.3	16,079	.63
Transportation, Communications and Public Utilities	35,852	56.7	17,067	.69
Wholesale Trade	30,876	73.2	14,213	.64
Retail Trade	26,140	67.4	13,026	.62
Finance, Insurance and Real Estate	63,660	57.3	12,878	.66
Business Services	43,697	45.8	13,010	.65
Professional and Related Services	54,466	67.2	10,024	.80
Public Administration	39,185	59.3	15,237	.65